A Laboratory Search for Variation of the Fine-Structure Constant Using Atomic Dysprosium

A. Cingöz, N. A. Leefer, and S. J. Ferrell
Department of Physics, University of California at Berkeley, Berkeley, California 94720-7300

A. Lapierre
Department of Physics, University of California at Berkeley, Berkeley, California 94720-7300 and TRIUMF National Laboratory, 4004 Wesbrook Mall, Vancouver, British Columbia, V6T 2A3, Canada

A.-T. Nguyen
Department of Neurobiology, University of Pittsburgh, Pittsburgh, Pennsylvania 15213

V. V. Yashchuk
Advanced Light Source Division, Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA

D. Budker
Department of Physics, University of California at Berkeley, Berkeley, California 94720-7300 and Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

S. K. Lamoreaux
Department of Physics, Yale University, New Haven, Connecticut 06520-8120

J. R. Torgerson
Physics Division, Los Alamos National Laboratory, P-23, MS-H803, Los Alamos, New Mexico 87545

Electric-dipole transitions between nearly degenerate, opposite parity levels of atomic dysprosium (Dy) are being monitored over time to search for a variation in the fine-structure constant, α. The frequencies of these transitions are sensitive to variation of α due to large relativistic corrections of opposite sign for the opposite-parity levels. In this unique system, in contrast to atomic-clock comparisons, the difference of the electronic energies of the opposite-parity levels can be monitored directly utilizing a radio-frequency (rf), electric-dipole transition between them. Our measurements for the frequency variation of the 3.1-MHz transition in ^{163}Dy and the 235-MHz transition in ^{162}Dy can be analyzed for both a temporal variation and a gravitational-potential dependence of α since, during the data acquisition period, the Earth is located at different values of the gravitational potential of the Sun. The data from our first eight-month run provided a rate of fractional temporal variation of α of $(-2.7 \pm 2.6) \times 10^{-15}$ yr^{-1} or a value of $(-8.7 \pm 6.6) \times 10^{-6}$ for k_α, the linear-variation coefficient for α in a changing gravitational potential, indicating the absence of significant variation at the present level of sensitivity. These results were reported in Phys. Rev. Lett. 98, 040801 (2007) and Phys. Rev. A 76(6), 062104 (2007). Progress in a new measurement designed to improve the sensitivity by more than two orders of magnitude will be reported at the meeting.